

Original Research Article

Application of Quick Simplex Method(A new approach) On Two Phase Method

ABSTRACT

In this article, a new approach is suggested while solving two phase simplex method. The method sometimes involves less iteration than in the simplex method or at the most an equal number because the method attempts to replace more than one basic variable simultaneously. While dealing with Two phase simplex method a new method [7] (quick simplex method) can be apply in Phase I and also in Phase II. This has been illustrated by giving the solution of Solving Two phase method problems. It is also shown that either the iterations required are the same or less but iterations required are never more than those of the simplex method.

KEY WORDS AND PHRASES : basic feasible solution, optimum solution, simplex method, key determinant, constraints, net evaluation

1.INTRODUCTION:

(i) the graphical method (ii) simplex The linear programming has its own importance in obtaining the solution of a problem where two or more activities complete for limited resources.

Mathematically we have to maximize the objective function cx

subject to $Ax = b$, $x \geq 0$

where

$x = n \times 1$ column vector

$A = m \times n$ coefficient matrix

$b = m \times 1$ column vector

$C = 1 \times n$ row vector

and the columns of A are denoted by $P_1, \dots, P_n$.

There are **two methods** to obtain the solution of the above problem. These methods can be classified as :

method.

There are various alternative approaches to solve Simplex methods and Two phase simplex method.

In this article, a new approach quick simplex method [7] is suggested while solving two phase simplex method. New method can be apply in Phase I and in Phase II

37 wherever applicable.

38 The method sometimes involves less iteration than in the simplex method or at the
39 most an equal number because the method attempts to replace more than one basic
40 variable simultaneously.

41 It is known that the conventional simplex method is rather inconvenient in handling
42 the degeneracy and cycling problems because here the choice of the vectors, entering
43 and outgoing, plays an important role. The degeneracy occurs when there is a tie for
44 outgoing vector. The possibility of cycling is crucial only if the current basic feasible
45 solution has more than one variable zero. In the simplex method when there arises a
46 tie for entering the vector, the vector with the lowest index j , is selected.

47 In our method the problem of tie in most of the degeneracy problems is solved. The
48 powerfulness of our method lies in getting rid of the tie in the degeneracy problems.
49 In such situations our technique positively is more powerful and handy as well.

50

51 **2. Quick Simplex Method :**

52

53 For the solution of any L.P.P. by simplex algorithm, the existence of an initial basic
54 feasible solution is always assumed. The steps for the computation of an optimum
55 solution are as follows:

56 Step 1) Check whether the objective functions of the given L.P.P. is maximized or
57 minimized .If it is minimized, convert it into a problem of maximizing by using the
58 result

59 Minimum $z = -\text{Maximum}(-z)$

60 Step 2) Check whether RHS of the constraints, q_i ($i=1,2,\dots,m$) are non-negative. If
61 any one q_i is negative, then multiply the corresponding inequalities of the constraints
62 by (-1) , so as to get all q_i ($i=1,2,\dots,m$) non-negative.

63 Step 3) Convert all the inequalities of the constraints into equations by introducing
64 slack and / or surplus variables in the constraints. Put the costs of these variables
65 equal to zero. Artificial variables can be used if needed.

66 Step 4) Obtain an initial basic feasible solution to the problem in the form $X_B = B^{-1}Q$
67 and put it in the last column of the simplex table.

- 68 Step 5) Compute the net evaluations $z_j - c_j$ ($j=1,2,\dots,n$) by using the relation
- 69 $z_j - c_j = C_B P_j - c_j$ where $P_j = B^{-1} a_j$
- 70 Here we assume that at least one $z_j - c_j$ is negative.
- 71 Step 6) Choose most negative net evaluation. Let it be $z_j - c_j$. Calculate the ratios
- 72 θ_{rj} for positive a_{rj} . If all the entries in j th column are negative then go for next most
- 73 negative net evaluation. If only one net evaluation say $z_j - c_j$ is negative and all the
- 74 entries in the j th column are negative, then the problem has unbounded solution and
- 75 procedure ends there otherwise goto the next step.
- 76 Step 7) Choose minimum θ_{rj} say θ_{kj} . Break the tie arbitrarily if any.
- 77 Step 8) Element of simplex table at the chosen element i.e. a_{kj} will be the pivotal
- 78 element.
- 79 Step 9) If number of pivotal element is less than m , then check if any more negative
- 80 net evaluation is left. If it is so go to step 7 ignoring row and column of pivotal
- 81 element otherwise go to the next step.
- 82 Step 10) Variables corresponding to the columns of pivotal elements are the incoming
- 83 variables in the basis and they replace the variables corresponding the row of the
- 84 pivotal elements. Note the number of pivotal elements say r . Then define key
- 85 determinant of order $(r \times r)$ by using submatrix of matrix A whose diagonal elements
- 86 are the pivotal elements.
- 87 Step 11) Calculate entries in X_B column using new basis, formed by using vectors
- 88 containing all the pivotal elements.
- 89 Step 12) If all the entries are non-negative then the above replacement of r variables is
- 90 allowable and next step can be followed otherwise the variable corresponding to the
- 91 negative value of the X_B column should not be entered in the basis. In such case goto
- 92 step number 15.
- 93 Step 13) Determine entries in the new simplex table by replacing the r variables

94 simultaneously.

95 Step 14) Check the optimality of the solution using net evaluations.

96 a) If all net evaluations are non-negative then the solution is optimal and procedure
97 ends there.

98 b) If at least one net evaluation is negative go to step 6 .

99 Step 15) Check if basis changes in case there was a tie , by choosing alternative
100 variable in the basis , otherwise instead of minimum θ_{rj} . Choose next minimum θ_{ri}
101 for which $z_i - c_i$ is negative and X_i was not in the basis. This should be done for all
102 those variables for which value of X_B column is obtained as negative. Now go to step
103 10 using this new basis.

104 **3. STATEMENT OF THE PROBLEM-I**

105 Use two phase simplex method to solve the following LPP

106 Maximize $z = 5x_1 + 8x_2$

107 Subject to the constraints :

108 $3x_1 + 2x_2 \geq 3$

109 $x_1 + 4x_2 \geq 4$

110 $x_1 + x_2 \leq 5$

111 $x_1, x_2 \geq 0$

112

113 **4. SOLUTION OF THE PROBLEM BY TWO PHASE SIMPLEX METHOD.**

114 **PHASE -I**

115

116 In this problem it is observed that an optimum basic feasible solution has been
117 reached by conventional simplex method in three step in phase I and again three steps
118 in phase II .

119 And solution is $x_1 = 0$ and $x_2 = 5$, and Max $Z = 40$.

120

121 **5. Here we apply quick simplex method for PHASE-I**

122

123

124

125

126 **Step (1):** (Initial table)

127

		0	0	0	-1	0	-1	0		Ratio 1	Ratio 2
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	x_B		
-1	x_5	$a_1 = 3$	$b_1 = 2$	-1	1	0	0	0	3	1	3/2
-1	x_6	$a_2 = 1$	$b_2 = 4$	0	0	-1	1	0	4	4	1
0	x_7	$a_3 = 1$	$b_3 = 1$	0	0	0	0	1	5	5	5
	$z_j - c_j$	-4	-6	1	0	1	0	0			
		↑	↑		↓		↓				

128

129 Here we introduce P_1, P_2 **Simultaneously** and **outgoing vectors** are P_4, P_6

130 **To find new values in X_B column.**

131 Here we can find c_1^{**}, c_2^{**} and c_3^{**} using following formula.[7]

132

133 **Column $X_B = \begin{bmatrix} 3 \\ 4 \\ 5 \end{bmatrix}$**

134

135

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & 3 \\ 4 & 4 \end{vmatrix}}{10} = 2/5, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & 3 \\ 1 & 4 \end{vmatrix}}{10} = 9/10,$$

136

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & 3 \\ 1 & 4 & 4 \\ 1 & 1 & 5 \end{vmatrix}}{10} = 37/10, \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

137

138 **New $X_B = \begin{bmatrix} 2/5 \\ 9/10 \\ 37/10 \end{bmatrix}$**

139

140 **To find other entries in third simplex table.**

$$141 \quad \text{Column } P_3 = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} : -$$

142

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & -1 \\ 4 & 0 \end{vmatrix}}{10} = -\frac{2}{5}, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & -1 \\ 1 & 0 \end{vmatrix}}{10} = 1/10,$$

143

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & -1 \\ 1 & 4 & 0 \\ 1 & 1 & 0 \end{vmatrix}}{10} = 3/10 \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

144

145

$$146 \quad \text{New } P_3 = \begin{bmatrix} -2/5 \\ 1/10 \\ 3/10 \end{bmatrix}$$

147 **To find other entries in third simplex table.**

$$148 \quad \text{Column } P_4 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} : -$$

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & 1 \\ 4 & 0 \end{vmatrix}}{10} = 2/5, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & 1 \\ 1 & 0 \end{vmatrix}}{10} = -1/10$$

149

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & 1 \\ 1 & 4 & 0 \\ 1 & 1 & 0 \end{vmatrix}}{10} = -3/10 \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

150

$$151 \quad \text{New Column } P_4 = \begin{bmatrix} 2/5 \\ -1/10 \\ -3/10 \end{bmatrix}$$

$$152 \quad \text{Column } P_5 = \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix} : -$$

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & 0 \\ 4 & -1 \end{vmatrix}}{10} = 1/5, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & 0 \\ 1 & -1 \end{vmatrix}}{10} = -3/10,$$

153

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & 0 \\ 1 & 4 & -1 \\ 1 & 1 & 0 \end{vmatrix}}{10} = 1/10 \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

154

155 New Column $P_5 = \begin{bmatrix} 1/5 \\ -3/10 \\ 1/10 \end{bmatrix}$

156

157 Column $P_6 = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} : -$

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & 0 \\ 4 & 1 \end{vmatrix}}{10} = -1/5, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & 0 \\ 1 & 1 \end{vmatrix}}{10} = 3/10$$

158

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & 0 \\ 1 & 4 & 1 \\ 1 & 1 & 0 \end{vmatrix}}{10} = -1/10, \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

159

160 New Column $P_6 = \begin{bmatrix} -1/5 \\ 3/10 \\ -1/10 \end{bmatrix}$

161 Column $P_7 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} : -$

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} 2 & 0 \\ 4 & 0 \end{vmatrix}}{10} = 0, \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 3 & 0 \\ 1 & 0 \end{vmatrix}}{10} = 0,$$

162

$$c_3^{**} = \frac{\begin{vmatrix} 3 & 2 & 0 \\ 1 & 4 & 0 \\ 1 & 1 & 1 \end{vmatrix}}{10} = 1 \quad R = \begin{vmatrix} 3 & 2 \\ 1 & 4 \end{vmatrix} = 10$$

163

164 New Column $P_7 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

165 So we get direct third simplex table using above formulae.

166 **Step (3):** Introduce P_1 and drop P_4

167

		0	0	0	-1	0	-1	0	
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	x_B
0	x_1	1	0	$-2/5$	$2/5$	$1/5$	$-1/5$	0	$2/5$
0	x_2	0	1	$1/10$	$-1/10$	$-3/10$	$3/10$	0	$9/10$
0	x_7	0	0	$3/10$	$-3/10$	$1/10$	$-1/10$	1	$37/10$
	$z_j - c_j$	0	0	0	1	0	1	0	

168

169 Since all $z_j - c_j \geq 0$, we go to **PHASE-II**

170 **Step (4):**

		5	8	0		0		0		Ratio1	Ratio2
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	x_B		
5	x_1	1	0	$b_1 = -2/5$		$a_1 = 1/5$		0	$2/5$	-ve	2
8	x_2	0	1	$b_2 = 1/10$		$a_2 = -3/10$		0	$9/10$	9	-ve
0	x_7	0	0	$b_3 = 3/10$		$a_3 = 1/10$		1	$37/10$	$37/3$	37
	$z_j - c_j$	0	0	$-6/5$		$-7/5$		0			
		↓	↓	↑		↑					

171

172 Here we introduce P_3, P_5 **Simultaneously** and outgoing vectors are P_2, P_1 .

173 **To find new values in X_B column.**

174 Here we can find c_1^{**} , c_2^{**} and c_3^{**} using following formula.

175

176 **Column X_B**
$$= \begin{bmatrix} 2/5 \\ 9/10 \\ 37/10 \end{bmatrix}$$

177

178

$$c_1^{**} = \frac{(-1)^1 \begin{vmatrix} -2/5 & 2/5 \\ 1/10 & 9/10 \end{vmatrix}}{-1/10} = -4 \quad c_2^{**} = \frac{(-1)^2 \begin{vmatrix} 1/5 & 2/5 \\ -3/10 & 9/10 \end{vmatrix}}{-1/10} = -3$$

179

180

$$c_3^{**} = \frac{\begin{vmatrix} 1/5 & -2/5 & 2/5 \\ -3/10 & 1/10 & 9/10 \\ 1/10 & 3/10 & 37/10 \end{vmatrix}}{-1/10} = 5 \quad R = \begin{vmatrix} 1/5 & -2/5 \\ -3/10 & 1/10 \end{vmatrix} = -1/10$$

181

182 **New X_B**
$$= \begin{bmatrix} -4 \\ -3 \\ 5 \end{bmatrix}$$

183

184 **Here we found entries in X_B Column are negative so here we have to apply**
 185 **conventional simplex method only.**

186 **Step (5):** Introduce P_5 and drop P_1

		5	8	0		0		0		Ratio
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	x_B	
0	x_5	5	0	-2		1		0	2	2
8	x_2	3/2	1	-1/2		0		0	3/2	-ve
0	x_7	-1/2	0	1/2		0		1	7/2	37
	$z_j - c_j$	7	0	-4		0		0		
				↑				↓		

187

188

189 **Step (6):** Introduce P_3 and drop P_7

190

		5	8	0		0		0	
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	x_B
0	x_5	3	0	0		1		4	16
8	x_2	1	1	0		0		1	5
0	x_3	-1	0	1		0		2	7
	$z_j - c_j$	3	0	0		0		8	

191

192 Since all $z_j - c_j \geq 0$, an optimum basic feasible solution has been reached.

193 $x_1 = 0$ and $x_2 = 5$, and Max $Z = 40$.

194 It is observed that we reached to solution in PHASE -1 in one step only by quick
 195 simplex method .while in conventional simplex we reached to solution after 2 step.
 196 here we got advantage of quick simplex method.

197

198 4.3.1 Example 2

199 Use two phase simplex method to solve the following LPP

200 Maximize $Z = -2x_1 - x_2$

201 Subject to the constraints :

202 $3x_1 + x_2 \geq 3$,

203 $4x_1 + 3x_2 \geq 6$

204 $x_1 + 2x_2 \geq 3$, $x_j \geq 0$

205 4.3.1.1 Problem modified in the standard form:

206 PHASE -I

207 Maximize $Max Z = 0x_1 + 0x_2 + 0x_3 - x_4 + 0x_5 - x_6 + 0x_7 - x_8$

208 Subject to the constraints :

209 $3x_1 + x_2 - x_3 + x_4 = 3$,

210 $4x_1 + 3x_2 - x_5 + x_6 = 6$,

211 $x_1 + 2x_2 - x_7 + x_8 = 3$, $x_j \geq 0$

212

213 **4.3.1.2 Solution to the problem using simplex method:**

214 In this problem it is observed that an optimum basic feasible solution has been
215 reached by conventional simplex method in four step in phase I and again in one step
216 in phase II .

217 And solution is $x_1 = 3/5$ and $x_2 = 6/5$, and Max Z = -12/5.

218 **4.1.2.3 Solution to the problem using quick simplex method:**

219

220 **PHASE-I**

221 **Step (1):** (Initial table)

222

		0	0	0	-1	0	-1	0	-1		R1	R 2
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	X_B		
-1	x_4	$a_1 = 3$	$b_1 = 1$	-1	1	0	0	0	0	3	1	3
-1	x_6	$a_3 = 4$	$b_3 = 3$	0	0	-1	1	0	0	6	3/2	2
-1	x_8	$a_2 = 1$	$b_2 = 2$	0	0	0	0	-1	1	3	3	3/2
	$z_j - c_j$	-8	-6	1	0	1	0	1	0			
		↑	↑		↓				↓			

223

224

225 Here we introduce P_1, P_2 Simultaneously and outgoing vectors are P_4, P_8 .

226 To find new values in X_B column. Using above formulae we find

227 New $X_B = \begin{bmatrix} 3/5 \\ 0 \\ 6/5 \end{bmatrix}$

228 Similarly We find other entries.

229 **Step(2):**

		0	0	0	-1	0	-1	0	-1		
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	x_B	
0	x_1	1	0	$-2/5$	$2/5$	0	0	$1/5$	$-1/5$	$3/5$	
0	x_6	0	0	1	-1	-1	1	1	-1	0	
0	x_2	0	1	$1/5$	$-1/5$	0	0	$-3/5$	$3/5$	$6/5$	
	$z_j - c_j$	0	0	0	1	0	1	0	1		

230

231 Since all $z_j - c_j \geq 0$, we go to **PHASE-II**

232 **Step(2):**

		-2	-1	0	-1	0	-1	0	-1		
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	x_B	
-2	x_1	1	0	$-2/5$	$2/5$	0	0	$1/5$	$-1/5$	$3/5$	
-1	x_6	0	0	1	-1	-1	1	1	-1	0	
-1	x_2	0	1	$1/5$	$-1/5$	0	0	$-3/5$	$3/5$	$6/5$	
	$z_j - c_j$	2	0	$-2/5$	$2/5$	1	0	$-4/5$	$4/5$		
							↓	↑			

233

234 **Step(3):** Introducing P_7 and dropping P_6

		-2	-1	0	-1	0	-1	0	-1		
C_B	X_B	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	x_B	

-2	x_1	1	0	$-3/5$	$3/5$	0	0	0	0	$3/5$	
0	x_7	0	0	1	-1	-1	1	1	-1	0	
-1	x_2	0	1	$4/5$	$-4/5$	$-3/5$	$3/5$	0	0	$6/5$	
	$z_j - c_j$	0	0	$2/5$	$3/5$	$3/5$	$2/5$	0	1		

235

236 Since all $z_j - c_j \geq 0$, an optimum basic feasible solution has been reached.

237 $x_1 = 3/5$ and $x_2 = 6/5$, and Max Z = $-12/5$.

238 In this problem it is observed that we reached a solution in PHASE -I in one step

239 only by quick simplex method, to which we reached after 3 steps when conventional

240 simplex method is used.

241 Hence the number of iterations required is reduced by Quick simplex algorithm
242 methodology. This method found to be more convenient when introducing more than
243 one vector simultaneously.

244 **Conclusion:** In the above problems it is observed that we reached to solution in
245 PHASE -1 in one step only by quick simplex method. While in conventional simplex
246 we reached to solution after 3 or more steps. Such advantage occurs by following
247 quick simplex method[7] in solving many linear programming problems.

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